Equipment Power Consumption and Cost for Enterprise Access Links - Source Data

Xiaoyu Wang*, Malathi Veeraraghavan*, Maïté Brandt-Pearce*, Takahiro Miyazaki†,
Naoaki Yamanaka†, Satoru Okamoto† and Ion Popescu‡ *University of Virginia, Charlottesville, VA 22904–4743,
{xw5ce, mvee, mb-p}@virginia.edu †Keio University, Kanagawa, Japan, {miyazaki, yamanaka,
okamoto}@yamanaka.ics.keio.ac.jp ‡Télécom Bretagne, Brest, France, ion.popescu@telecom-bretagne.eu

I. Power

TABLE I: Power consumption values in the static solution

Component	Manuf.	Description	Power Max. (W)	Power Used (W)[1]	Source
$I_C(R_{1s})$, $I_C(R_{3s})$	Juniper	MPC3E (MX-MPC3E-3D) + 100 GE MIC with CFP (MIC3-3D-1X100GE-CFP)	480+40	468	[1]
$O_C(R_{3s})$,$O_P(R_{4s})$	Cisco	100-Gbps coherent DWDM trunk card + 2-Port CFP Line Card	133+84	204[2]	[2], [3]
$D_C(R_{1s})$	Juniper	EX9200-2C-8XS line card	610	530	[4]
$I_P(R_{4s})$	Cisco	MSC card (CRS-MSC-140G) + 100 GE PLIM with CFP optics module	446+150	536	[5]

TABLE II: Power consumption values in the dynamic solution

Component	Manuf.	Description	Power Max. (W)	Power Used (W)	Source
$O_C(R_{3d})$	Transmode	double 10GbE lite transponder	18	16.2	[6]
$I_C(R_{3d})$	Juniper	FPC3 (M320-FPC3) + 10 GE DWDM PIC (PC-1XGE-DWDM-CBAND)	160+26.6	168	[7], [8]
$O_C(\mathrm{MD_{4ch}})$, $O_P(\mathrm{MD_{4ch}})$	BTI	7000 series 8-ch DWDM Mux/Demux (BP1A35AX (A-D))	passive element	0	[9]
$O_C(R_{2d})$, $O_P(R_{2d})$	Cisco	100-Gbps coherent DWDM trunk card + 2-Port CFP Line Card	133+84	204[2]	[2], [3]
$D_C(R_{2d})$	Juniper	EX9200-2C-8XS line card	610	530	[4]
$O_P(R_{3d})$	Transmode	quad 10G multi-service transponder	50	45 (4 ports)[3]	[10]
$I_P(R_{3d})$	Juniper	MPC2 (MX-MPC2-3D) + 10 GE MIC with XFP (MIC-3D-2XGE-XFP)	274+29	298.8 (4 ports)[4]	[7]
$I_P(R_{2d})$	Juniper	MPC6E (MX2K-MPC6E) + 4 100 GE MIC with CXP (MIC6-100G-CXP)	984+57	936.9 (4 ports)[4]	[11], [12]
$O_P(\mathrm{PS})_a$	Glimmerglass	IntellIgent optIcal system 100	50	50	[13]
$O_P(\mathrm{MD_{40ch}})_b$	BTI	7000 series 40-ch Mux/Demux (BT7A37AA / BT7A37CA)	passive element	0	[9]
$O_P(\mathrm{WSS})_b$	Cisco	40-ch wavelength selective switch (15454-40-WSS-C)	79	63	[14]

Notes:

1. Most of the power consumption values provided in datasheets are the maximum power budget and thus represent an upper limit and not typical values of power consumption at full load. [15] Therefore, if the typical power consumption of a component is explicitly given in the datasheet, it is used in the paper. Otherwise, the power value used is derived as 90% of the given maximum power consumption.
2. Although the power value 204 W includes the power consumed by two ports and $O_C(R_{2d})$ in both the static and dynamic solutions require only one port, the power consumption of each component is still counted as 204 W. Since here we assume that the ports cannot be turned off individually. In contrast, in the provider network, there would be multiple active ports for $O_P(R_{2d})$. Hence, the power values are calculated as $204\lceil\frac{K}{2}\rceil$ and $204\lceil\frac{KU}{2}\rceil$, respectively in the static and dynamic solutions, given the number of customer networks K and the system utilization U as defined in the paper.
3. The power value 45 W is for a 4-port card. We assume again that each individual port cannot be powered off to save energy. So the power consumption of $O_P(R_{3d})$ is computed as $45\lceil\frac{K}{4}\rceil$.
4. The power consumption values of $I_P(R_{3d})$ and $I_P(R_{2d})$ are derived similar as the one of $O_P(R_{3d})$ described above.

TABLE III: Cost values in the static solution

Component	Description	Available	Cost (SCU)[5]
$I_C(R_{1s})$, $I_C(R_{3s})$	1×100 GE IP/MPLS metro/access router line card + 100G short-reach transceiver	2012	29.36+1.00
$O_C(R_{3s})$,$O_P(R_{4s})$	100G DWDM transponder, 2000km	2012	15.00
$D_C(R_{1s})$[6]	-	-	-
$I_P(R_{4s})$	1×100 GE IP/MPLS core router line card + 100G short-reach transceiver	2012	34.28+1.00

TABLE IV: Cost values in the dynamic solution

Component	Description	Available	Cost (SCU)
$O_C(R_{3d})$, $O_P(R_{3d})$	10G DWDM transponder	2012	1
$I_C(R_{3d})$	1×10GE IP/MPLS metro/access router line card + 10G short-reach transceiver	2012	2[7]+0.1
$O_C(\mathrm{MD}_{4\mathrm{ch}})$, $O_P(\mathrm{MD}_{4\mathrm{ch}})$		-	0.1[8]
$O_C(R_{2d})$, $O_P(R_{2d})$	100G DWDM transponder, 2000km	2012	15
$D_C(R_{2d})$[6]	-	-	-
$I_P(R_{3d})$	14×10GE IP/MPLS core router line card + 10G short-reach transceiver	2012	31.98+14×0.1 = 33.38 (14 ports)[9]
$I_P(R_{2d})$	1×100 GE IP/MPLS core router line card + 100G short-reach transceiver	2012	34.28+1.00
$O_P(\mathrm{PS})_a$	Glimmerglass photonic cross-connect	-	3.25[10]
$O_P(\mathrm{MD}_{40\mathrm{ch}})_b$	40-channel AWG	-	0.9
$O_P(\mathrm{WSS})_b$	WSS 1×9 (including splitter and filter)	-	4

II. Cost

Notes:

5. One STRONGEST Cost Unit (SCU) corresponds to the 2012 cost of a 10GE optical transponder with a reach of 750 km. STRONGEST is the name of a European Union FP7 project. The cost values used in our paper all come from the paper [16] if not stated otherwise.

6. Since the DTN clusters D_C are common components for the static and dynamic solutions, their cost value is not needed when computing cost savings.

7. The cost of a 14×10GE IP/MPLS router line card in 2012 is 24.92. Since the router in a customer network of the dynamic design only needs one 10GE port, here we conservatively assume that a 1×10GE line card costs 2 SCUs.

8. The price of a Cisco 8-Ch CWDM Mux/Dmx Module is $3,100 (available at http://www.ithsc.com/ciscohardwaremaintenance/ONS-15216-15216-FLC-CWDM-8-155_2656-p-553540.html). Given that a 10G transponder costs around $40K (the prices of two Cisco 10G transponder card can be found on websites http://www.plchardware.com/Products/12/891741/5400978/CS-15454-10E-L1-C%3d.aspx and http://www.plchardware.com/Products/12/891741/5400978/CS-15454-10EX-L1-C%3d.aspx.), the SCU of the mux/demux is computed as $3,100/$40K≈0.1.

9. Since one line card supports 14 10GE ports, given the number of customer network K, the cost of $I_P(R_{3d})$ is $31.98\lceil\frac{K}{14}\rceil + 0.1K$. Besides, this card is not suitable for the customer networks, since each customer network only needs one 10GE port in our design.

10. Given the price of the Glimmerglass optical cross-connect $130K we found on the Japanese website (http://www.itmedia.co.jp/enterprise/articles/0603/14/news004.html) and that a 10G transponder cost around $40K, the SCU is calculated as $130K/$40K=3.25.

REFERENCES

[1] "Juniper MX series 3D universal edge router interface module reference," http://www.juniper.net/techpubs/en_US/release-independent/junos/information-products/topic-collections/hardware/mx-series/common/line-card-guide/mx-series-line-card-guide.pdf.

[2] "Cisco 100-Gbps coherent DWDM trunk card," http://www.cisco.com/c/en/us/products/collateral/optical-networking/ons-15454-series-multiservice-provisioning-platforms/data_sheet_c78-713298.pdf.

[3] "Cisco ONS 15454 2-port CFP line card," http://www.cisco.com/c/en/us/products/collateral/optical-networking/ons-15454-series-multiservice-provisioning-platforms/data_sheet_c78-713295.pdf.

[4] "Juniper EX9200 Ethernet switch datasheet," http://www.juniper.net/assets/us/en/local/pdf/datasheets/1000432-en.pdf.

[5] "Cisco CRS carrier routing system 16-slot line card chassis system description," http://www.cisco.com/c/en/us/td/docs/routers/crs/crs1/16_slot_lc/system_description/reference/guide/qsysdsc.pdf.

[6] "Transmode double 10G lite transponder datasheet," http://www.transmode.com/en/resource/datasheet/tm-series/layer-1-transponders/ds-tm-tpd10g-lite-c.

[7] "Juniper M320 multiservice edge router hardware guide," http://www.juniper.net/techpubs/en_US/release-independent/junos/information-products/pathway-pages/m-series/m320/index.pdf.

[8] "Juniper PIC/FPC compatibility (M320 router)," https://www.juniper.net/techpubs/hardware/m-series/m320/m320-pic/picfpc-compatibility-m320-router.html#jN129BF.

[9] "BTI 7000 series network multiplexing family," https://www.btisystems.com/Portals/0/Documents/Data-Sheets/Network-Multiplexing-Family-DS0045.pdf.

[10] "Transmode quad 10G multi-service transponder datasheet," https://www.transmode.com/en/resource/datasheet/tm-series/layer-1-transponders/quad-10g-multi-service-transponder-one-slot.

[11] "Juniper MPC6E," http://www.juniper.net/techpubs/en_US/release-independent/junos/topics/reference/general/mpc6e.html.

[12] "Juniper 100-Gigabit Ethernet MIC with CXP," http://www.juniper.net/techpubs/en_US/release-independent/junos/topics/reference/general/mic-mx2010-2020-100-gigabit-ethernet-cxp-description.html.

[13] "Glimmerglass intelligent optical system 100," http://www.juniper.net/techpubs/en_US/release-independent/junos/topics/reference/general/mpc6e.html.

[14] "40-channel reconfigurable optical add/drop multiplexing portfolio for the Cisco ONS 15454 multiservice transport platform," http://www.cisco.com/c/en/us/products/collateral/optical-networking/ons-15454-series-multiservice-provisioning-platforms/product_data_sheet0900aecd805ebf1d.pdf.

[15] W. VanHeddeghem and F. Idzikowski, "Equipment power consumption in optical multilayer networks-source data," Technical Report IBCN-12-001-01.

[16] F. Rambach, B. Konrad, L. Dembeck, U. Gebhard, M. Gunkel, M. Quagliotti, L. Serra, and V. Lopez, "A multilayer cost model for metro/core networks," *Optical Communications and Networking, IEEE/OSA Journal of*, vol. 5, no. 3, pp. 210–225, March 2013.